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IS 10209 (1982): Electroplated coatings of tin-lead alloy  
(solder) [MTD 7: Light Metals and their Alloys]



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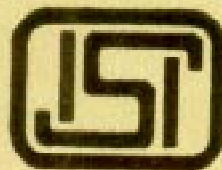
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SPECIFICATION FOR  
ELECTROPLATED COATINGS OF TIN-LEAD  
ALLOY ( SOLDER )

UDC 669.65.487



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**INDIAN STANDARDS INSTITUTION**  
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG  
NEW DELHI 110002

# *Indian Standard*

## SPECIFICATION FOR ELECTROPLATED COATINGS OF TIN-LEAD ALLOY ( SOLDER )

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# *Indian Standard*

## SPECIFICATION FOR ELECTROPLATED COATINGS OF TIN-LEAD ALLOY (SOLDER)

### 0. FOREWORD

**0.1** This Indian Standard was adopted by the Indian Standards Institution on 17 May 1982, after the draft finalized by the Metallic Finishes Sectional Committee had been approved by the Structural and Metals Division Council.

**0.2** The closeness of standard electrode potential of lead and tin makes the deposition of the alloy one of the simplest of alloy plating processes. Lead-tin alloys are among the small number of electrodeposited alloys which have found extensive commercial applications. The alloys are finer grained and more corrosion resistant than their parent metals and, consequently, have some advantages over the individual metals for industrial application.

**0.2.1** Since tin and lead may be readily plated from fluoborate solutions, it follows that solder may be readily deposited from fluoborate baths. Lead-tin plating baths find wide use in electronic equipment.

**0.3** Some corrosion of tin-lead coatings may be expected in outdoor exposure. In normal indoor exposure, tin-lead is protective on iron, copper, and copper alloys. Corrosion may be expected at discontinuities (pits or pores) in the coating. Porosity decreases as the thickness is increased. A primary use of the tin-lead coating (solder) is with the printed circuit industry as a solderable coating and as an etch mask material.

**0.4** In the preparation of this standard, assistance has been derived from ASTM B 579-1973, issued by the American Society for Testing and Materials.

**0.5** For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS:2-1960\*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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\*Rules for rounding off numerical values (*revised*).

## **1. SCOPE**

**1.1** This Indian Standard covers requirements of electrodeposited tin-lead coatings on fabricated articles of iron, steel, copper, and copper alloys, to protect them against corrosion, to improve and preserve solderability over long periods of storage, and to improve anti-galling characteristics.

**1.2** This standard applies to electrodeposited coatings containing a minimum of 50 percent and a maximum of 70 percent tin. The specification applies to mat bright, and flow-brightened tin-lead coatings.

**1.3** This standard does not apply to sheet, strip, or wire in the unfabricated form, or to threaded articles having basic major diameters up to and including 20 mm.

## **2. SIGNIFICANT SURFACES**

**2.1** Significant surfaces are defined as those surfaces normally visible (directly or by reflection) that are essential to the appearance or serviceability of the article when assembled in normal position; or those surfaces that may be the source of corrosion products that may deface visible surfaces of the assembled article. When necessary, the significant surfaces shall be indicated on the drawing of the part, or by the provision of suitably marked samples.

**NOTE** — When significant surfaces include areas on which the specified thickness of deposit may not readily be controlled, such as, threads, holes, deep recesses, bases of angles, and similar areas, the purchaser and the manufacturer should recognize the necessity for either thicker deposits on the more accessible surfaces, or for special racking. Special racks involve the use of conforming, auxiliary bipolar electrodes, or conducting shields.

## **3. MANUFACTURE**

**3.1** Tin-lead electroplating baths are composed of tin and lead fluoborates and of addition agents to promote stability. The final appearance may be influenced by the addition of proprietary brighteners. Without brighteners the coating are mat; with brighteners, they are semibright or bright. Flow brightened coatings are obtained by heating mat coatings to a temperature above the melting point of tin-lead for 2-10 seconds, and then quenching; palm oil, hydrogenated oils, or fats are used as a heat-transfer medium at a temperature of  $260 \pm 10^{\circ}\text{C}$ , but other methods of heating are also in use.

**3.1.1** Acidity of the quenching oil is very important. Generally it shall have a neutralization value of 3-6 mg KOH per gram of oil. The maximum thickness for flow-brightening shall not exceed  $7.5 \mu\text{m}$  and the minimum thickness shall be  $3 \mu\text{m}$ ; thicker coatings tend to reflow unevenly.



The shape of the part is also a factor; flat surfaces tend to reflow more unevenly than wires or rounded shapes, after flow melting it is necessary to remove the residual oil from the component.

**NOTE** — Volatile impurities in tin-lead coatings will cause bubbling and foaming during flow-brightening, resulting in voids and roughness. The impurities may arise from the addition in electroplating solution and from improper rinsing and processing.

**3.2** Defects in the surface of the basis metal, such as, scratches, porosity, nonconducting inclusion, roll and die marks, cold shuts and cracks, may adversely effect the appearance and the performance of coatings applied thereto, despite the observance of the best electroplating practices. Accordingly, the electroplater's responsibility for defects in the coating resulting from such conditions shall be waived, except when he is also in the position of prime contractor supplying these electroplated parts.

**NOTE** — To minimize problems of this sort, the specification covering the basis material or the item to be electroplated should contain appropriate limitations on such basis metal conditions.

**3.3** When required, the basis metal shall be subjected to such polishing or buffing operations as are necessary to yield deposits with the desired final appearance ( *see 5* ).

**3.4** Proper preparatory procedures and thorough cleaning of the basis metal surface are essential to assure satisfactory adhesion and corrosion performance of the coating.

**3.5** When necessary preliminary samples showing the finish shall be supplied to and approved by the purchaser. Where rack marks are inevitable, their location shall be the subject of agreement between the supplier and the purchaser.

## 4. CLASSIFICATION AND SERVICE CONDITION

**4.1** Orders for articles to be electroplated in accordance with this specification shall specify, in addition to this standard number, the classification notation indicating the basis metal and thickness of tin-lead coating required, or the service condition, when specifying a tin-lead coating composition, the first number shall refer to the tin content in mass percent.

### 4.1.1 Classification Notation

#### Symbol

Fe/  
Cu/  
/Sn-Pb

#### Classification

Iron or steel basis metals  
Copper or copper alloy basis metals  
Tin-lead coating and its composition number, when required; for example, Sn60-Pb40

Number ( 5 to 50 )	Minimum coating thickness in micrometres
Suffix Letter	
<i>f</i>	Flow-brightened
<i>b</i>	Bright
<i>m</i>	Mat

An example of complete classification notation is as follows:

Cu/Sn60-Pb40/5*f*

#### 4.1.2 Service Condition Number

No.	Service Condition
4	Very severe exposure
3	Severe exposure
2	Moderate exposure
1	Mild exposure

NOTE — See A-1 for additional description of exposure conditions, and examples of typical end uses. The coating thicknesses given for each service condition are guidelines, and are not intended to be absolute values.

## 5. PHYSICAL REQUIREMENTS

**5.1 Composition** — The tin-lead coating composition shall be as follows ( see Note ):

Element	Mass, percent
Tin ( Sn )	50 to 70
Lead ( Pb )	Remainder

**5.1.1** The percent tin is calculated as follows:

$$\text{Tin, percent} = 134.1 \times ( L/A - 1 )$$

where

*L* = mass of lead coating, g; and

*A* = mass of alloy coating, g.

NOTE — Only the tin content need be determined. Lead is usually determined by difference. A sample of the deposit may be obtained by electroplating on a stainless steel panel from which the coating may be peeled or by employing any recognized stripping method. The alloy composition of the deposit may be determined by methods, such as, gravimetric or volumetric analysis, density measurements and atomic absorption spectrophotometry.

In addition, the alloy composition produced by an electroplating solution may be obtained by comparing the weight of a tin-lead coating deposited by a given number of ampere-hours to the weight of lead coating produced in a lead fluoborate coulometer in series with the plating bath.

**5.2 Appearance** — The tin-lead coating (grey in colour) shall be smooth, fine grained, continuous, adherent, and shall be free of visible blisters, bits, nodules, indications of burning, excessive build-up, staining, and other defects. Flow-brightened coatings shall not have dewetted areas or beads, and shall be free of the oil used in the fusion process.

**5.3 Thickness** — The thickness of the coating on significant surfaces shall conform to the requirements given in Tables 1 and 2.

**5.3.1 Thickness Measurements** — Tin-lead alloy thickness measurements shall be made on those areas of the significant surfaces where the coating would be expected to be thinnest. The method of determining the thickness shall be specified by the purchaser. Several methods are available depending upon the thickness of coating, the shape of the article, and the basis metal. They include coulometric, magnetic and microscopical method.

**5.4 Adhesion** — The adhesion of the coating shall be adequate to pass the tests described in 8.2.

## 5.5 Solderability

**5.5.1** When specified by the purchaser, the coating shall be tested by one of the methods described in 8.3. The results shall be evaluated in accordance with each procedure described in that clause.

**5.5.2** When specified by the purchaser, the coating on copper and copper alloys shall, before solderability testing, be subjected to the preliminary artificial ageing treatment described in 8.3.6, to determine if they may be expected to retain their solderability during periods of storage.

NOTE — See A-2 for design considerations that have an effect on the selection of thickness of the coating, and, ultimately, on the solderability of the electro-deposits.

## 6. HYDROGEN EMBRITTLEMENT

**6.1** High-tensile strength steels, and severely cold-worked steels, are susceptible to embrittlement by hydrogen in both cleaning and electroplating operations. The embrittling hydrogen shall be removed by heat treatment at a temperature not exceeding 180°C.

## 7. SAMPLING

**7.1** Test methods are time consuming and often destructive; therefore, 100 percent inspection is usually impractical. The purchaser should select a suitable sampling plan for the acceptance testing of lots of coated items. In order that the manufacturer (electroplater) may know the quality standard he is expected to meet, the plan selected should be made part of the purchase contract.

## 8. TEST METHODS

### 8.1 Thickness

**8.1.1** Local thickness of the coating shall be measured by the methods prescribed in IS : 3203-1982\*.

**8.1.2** To meet the thickness specifications of the coatings, the electroplater is advised to:

- a) maintain regular control of all solutions,
- b) inspect the equipment at regular intervals, and
- c) check thickness at periodic intervals.

### 8.2 Adhesion

**8.2.1 Burnishing Test** — An area of not more than 650 mm<sup>2</sup> of the coated surface, selected at the discretion of the inspector shall be rubbed rapidly and firmly for 15 seconds with a smooth metal implement. A suitable burnishing implement is a copper or steel disk used edgewise and broadside. A pressure sufficient to burnish the coating shall be maintained at every stroke, but not so great as to cut it. Poor adhesion will be shown by the appearance of a loose blister which grows as burnishing is continued. If the quality of the coating is poor also, the blister may crack and the coating peel away from the basis metal.

**8.2.2 Quenching Test** — The coated article shall be heated in an oven for a sufficient time to reach  $150 \pm 10^{\circ}\text{C}$ , and quenched in room-temperature water. The adhesion is inadequate if the coating blisters, cracks, or peels.

**8.2.3 Reflow Test** — The coated articles shall be immersed in a bath of palm oil at a temperature of 200-250°C until the deposit melts. A bright coating completely covering the significant surfaces indicates adequate adhesion. The acidity shall be maintained as indicated in 3.1.1.

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\*Method of testing local thickness of electroplated coatings (first revision).

**8.2.4 Bend Test** — The samples shall be bent with the coated surface away, over a mandrel until its two legs are parallel. The mandrel shall have a diameter equal to the thickness of the sample. Examination at 4X magnification should show no evidence of peeling or cracking.

## 8.3 Solderability

### 8.3.1 General

**8.3.1.1** Methods for testing the solderability of tin-lead coated articles are based on the measurement of the extent of wetting by molten solder, or the determination of the minimum time required to produce full or perfect wetting by solder.

**8.3.1.2** The extent of wetting may be observed by manual or automatic immersion in molten solder under controlled conditions.

**8.3.1.3** The minimum wetting time may be determined by carrying a specimen in a fixture through a standing wave of solder at a controlled speed, and by measuring the shortest time of immersion that will give complete wetting.

### 8.3.2 Dip Tests ( Non-Automated )

**8.3.2.1 Sample** — For small articles of suitable shape and size the whole article for testing may be taken. For larger articles, a portion of suitable size for testing shall be cut. A recommended panel size is 25 mm<sup>2</sup>. For articles not falling into these categories, samples as agreed between the electroplater and the purchaser may be taken.

**8.3.3 Dip Tests (Automated)** — The use of automated testers eliminates possible operator errors, and assures repeatable results; in these units, the dipping operation, temperature control, and timing sequences are automated. One available unit provides a means for testing flat surfaces, wires, and component terminations by vertical immersion into the solder; in addition, a holding fixture is available to lower wire samples horizontally and face down through the solder, the speed of rotation being varied to produce a range of immersion times. Progressively contact times with the solder may be increased by using separate specimens, and the least time required for complete wetting and the onset of dewetting by visual examination of the series of specimens may be determined. The best conditions of solderability would have the shortest wetting time, and would show no signs of dewetting within the longest contact time required. A minimum wetting time under 2 seconds is evidence of good solderability. An auxiliary attachment may be made available for the determination of spread values. The specimen is lowered on to the surface of the solder and a delay timer built into the

equipment holds the test piece in contact with the solder for any preselected time up to 10 seconds. Spread values may be determined as given in 8.3.4.

### 8.3.4 Spread Test

**8.3.4.1** This method involves placement of a fixed volume of solder on the surface of a specimen with a few drops of rosin flux, and heating the specimen for a fixed period of time at a controlled temperature.

**8.3.4.2** The area of spread may be measured with a planimeter and the height of the solder blob may be measured with a stage micrometer which may be set to subtract the thickness of the basis metal and the 'spread factor' calculated. A hot plate held at  $250 \pm 5^\circ\text{C}$  may be used as a source of heat.

### 8.3.5 Globule Test

**8.3.5.1** This test method was devised for assessing the solderability of wires, component leads, etc.

**8.3.5.2** The method consists of lowering the specimen of wire ( or component lead ) previously fluxed, horizontally onto a molten globule of solder, which is thereby cut in two. The time in seconds for the solder to flow around the wire and unite above it, is a measure of the solderability. Fresh pellet of solder shall be used for each test, the size of the pellet being determined by the diameter of the specimen wire.

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**TABLE 1 TIN-LEAD ALLOY COATINGS ON STEEL**

( Clause 5.3 )

SERVICE CONDITION	CLASSIFICATION NUMBER	MINIMUM THICKNESS $\mu\text{m}$
4*	Fe/SnPb 30	30
3*	Fe/SnPb 20	20
2	Fe/SnPb 10	10
1	Fe/SnPb 5	5
1	Fe/SnPb 5ff†	5

\*An undercoat of  $2.5 \mu\text{m}$  copper is recommended for service conditions 3 and 4.

ff = flow-brightened or

m = mat or

b = bright

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### 8.3.6 Artificial Aging (When Specified by the Purchaser)

**8.3.6.1** The sample for test shall be placed in a suitable vessel above boiling water and left, with the water boiling continuously, for 24 hours. The vessel shall be covered to ensure that the sample shall not come into contact with the wall of the vessel, and that its lower edge shall not be less than 50 mm or more than 100 mm above the surface of the boiling water. Arrange the cover on the vessel and the steam condenser, if used, so that they do not discharge condensed water over the sample. Any discoloration of the sample occurring during this aging treatment shall be removed. After the 24 hour treatment, the sample shall be removed from the steam, and allowed to dry in the air.

**8.3.6.2** Test methods outlined in 8.3.2, 8.3.3, 8.3.4 or 8.3.5 are used to assess the solderability of the aged specimens.

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**TABLE 2 TIN-LEAD ALLOY COATINGS ON COPPER, COPPER ALLOYS\* AND NON METALS†**

( Clause 5.3 )

SERVICE CONDITION	CLASSIFICATION NUMBER	MINIMUM THICKNESS μm
4	Cu/SnPb 30	30
3	Cu/SnPb 15	15
2	Cu/SnPb 8	8
1	Cu/SnPb 5	5
1	Cu/SnPb 5f‡	5

\*If the basis metal is a brass containing more than 15 percent zinc the tin-lead coating shall be preceded by an undercoat of at least 2.5 μm of copper or nickel to prevent the diffusion of zinc into the tin-lead. The same undercoating shall also be applied when the basis metal is beryllium copper to assure adhesion of tin-lead coating.

†Non-metals shall be suitably sensitized and metallized prior to tin-lead coating.

‡f = flow-brightened or

m = mat or

b = bright

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## 9. MARKING

**9.1** The marking related to the coating shall include classification number as specified in this standard and the name or trade-mark of the electroplater.

**9.1.1** The coated articles may also be marked with the ISI Certification Mark which shall relate to the coating of the article.

**NOTE** — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution ( Certification Marks ) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

## APPENDIX A

( *Clauses 4.1.2 and 5.5.2* )

### SERVICE CONDITIONS AND DESIGN CONSIDERATION

#### A-1. EXAMPLES OF SERVICE CONDITIONS

**A-1.1 Service Condition 4** — Very severe service conditions require a complete coating of tin-lead, free of pores. If the coating is subjected to abrasion or is exposed to corrosive liquids or gases, a deposit of 30 to 125  $\mu\text{m}$  may be required to maintain maximum protection.

**A-1.2 Service Condition 3** — Severe conditions include exposure to dampness and to industrial atmospheres. Coatings of 12 to 30  $\mu\text{m}$  have been reported to be satisfactory, particularly for preserving a solderable coating after a long storage period ( for example, 9 months ). Another application considered in this category is the use of the tin-lead as an etch resist in the production of printed-circuit boards.

**A-1.3 Service Condition 2** — Moderate service conditions include dry or interior atmosphere. Coatings of 8 to 12  $\mu\text{m}$ , after flow-brightening, have been reported to be satisfactory, particularly for preserving a solderable coating for a shorter storage period than that given in Service Condition 3. Also, as in Service Condition 3, another application considered in this category is the use of the tin-lead as an etch resist in the production of printed-circuit boards.

**A-1.4 Service Condition 1** — Mild service conditions with less severe requirements than Service Condition 2. Deposits of 5  $\mu\text{m}$  and less have been reported satisfactory for providing and preserving a solderable coating for short periods of storage ( for example, 3 months ).

#### A-2. DESIGN CONSIDERATIONS

##### A-2.1 General

**A-2.1.1** The properties of electrodeposited tin-lead coatings satisfy the requirements of solderability, corrosion resistance, etc, outlined in the



scope of this specification and their use may be recommended for most applications. Attention is drawn to the effects of temperature and to long-term storage of tin-lead electroplated articles which may be factors in designing for special applications.

### **A-2.1.2** *Temperature Effects*

**A-2.1.2.1** Tin-lead coatings are soft and will withstand considerable flexing and twisting of the basis metal without serious damage. At room temperature, mat tin-lead coatings will oxidize slowly, but flow-brightened and bright tin-lead coatings oxidize less readily.

**A-2.1.2.2** Interdiffusion between tin-lead coatings and copper or copper alloys does take place. The diffusion is slow at room temperature, and rapid at elevated temperatures. Evidence of diffusion is the formation of a layer of copper-tin compound at the interface, and diffusion of zinc to the surface if the substrate is brass. Diffusion may lead to darkening of a thin coating, and impairment of its solderability, particularly after long storage. With such thin coatings, a diffusion barrier of nickel may be advantageous, but users should consider the use of a thicker coating when solderability has to be maintained over a period of years. An undercoat of nickel or copper shall be used as a diffusion barrier on brass.

# INDIAN STANDARDS

## ON

## ELECTROPLATING

IS :

- 1067-1981 Electroplated coatings of silver for decorative and protective purposes  
( *first revision* )
- 1068-1968 Electroplated coatings of nickel and chromium on iron and steel  
( *first revision* )
- 1337-1980 Electroplated coatings of hard chromium on iron and steel ( *second revision* )
- 1359-1977 Electroplated coatings of tin ( *second revision* )
- 1378-1979 Oxidised copper finishes ( *second revision* )
- 1572-1968 Electroplated coatings of cadmium on iron and steel ( *first revision* )
- 1573-1970 Electroplated coatings of zinc on iron and steel ( *first revision* )
- 1771-1970 Electroplated coatings of silver for general engineering purposes  
( *first revision* )
- 1772-1972 Electroplated coatings of copper ( *first revision* )
- 1773-1961 Brass plating
- 1992-1979 Electroplated coatings of lead ( *first revision* )
- 4827-1968 Electroplated coatings of nickel and chromium on copper and copper alloys
- 4828-1968 Electroplated coatings of nickel and chromium on aluminium and aluminium alloys
- 4942-1968 Electroplated coatings of nickel and chromium on zinc and zinc alloys
- 8376-1977 Electroplated coatings of nickel and chromium on plastics for decorative purposes